

Recommendations

- My recommendation is that full-scale RCP testing and S4 RCP testing should be conducted on current commercially available butt fused PVC pipe to determine the RCP Full-Scale Critical Pressure.
- Testing needs to be done on various pipe sizes and dimension ratios to determine diameter and wall thickness effects.



Recommendations

The following requirements should be added to industry standards for butt fused PVC pipe:

- The PVC pipe internal pressure during both operation and leak pressure testing shall be maintained below the PVC pipe full-scale RCP critical pressure.
- In the event that PVC pipe RCP critical pressure data are not available, then the DR of the butt fused PVC pipe shall be DR 13 or lower – e.g. DR 11 or DR 9.



Conclusions

- RCP is a failure mode that is infrequent, but possible to occur under certain conditions with an initiating event.
- An understanding of design practices and material properties is recommended.
- RCP events in PE pipe are not possible for typical water filled PE pipes and P_c for a PE was shown to be greater than the pipe's Pressure Rating.
- Based on test results and field experience, RCP events in PVC pipes are possible and P_c may be less than the pipe's Pressure Rating.



OUTLINE

RCP Failures in Butt Fused PVC Pipe

- Known RCP Field Failures in Butt Fused PVC Pipe
- RCP Laboratory Data for PVC Pipe
- Proposals to Prevent RCP Failures in FPVC

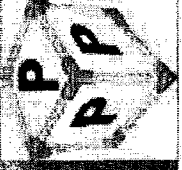
Butt Fusion Failures in PVC Pipe

- Known Butt Fusion Field Failures in PVC Pipe
- Joint Integrity Laboratory Data for PVC Pipe
- Proposals to Prevent BF Failures in FPVC

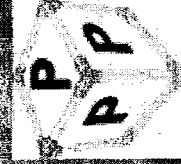
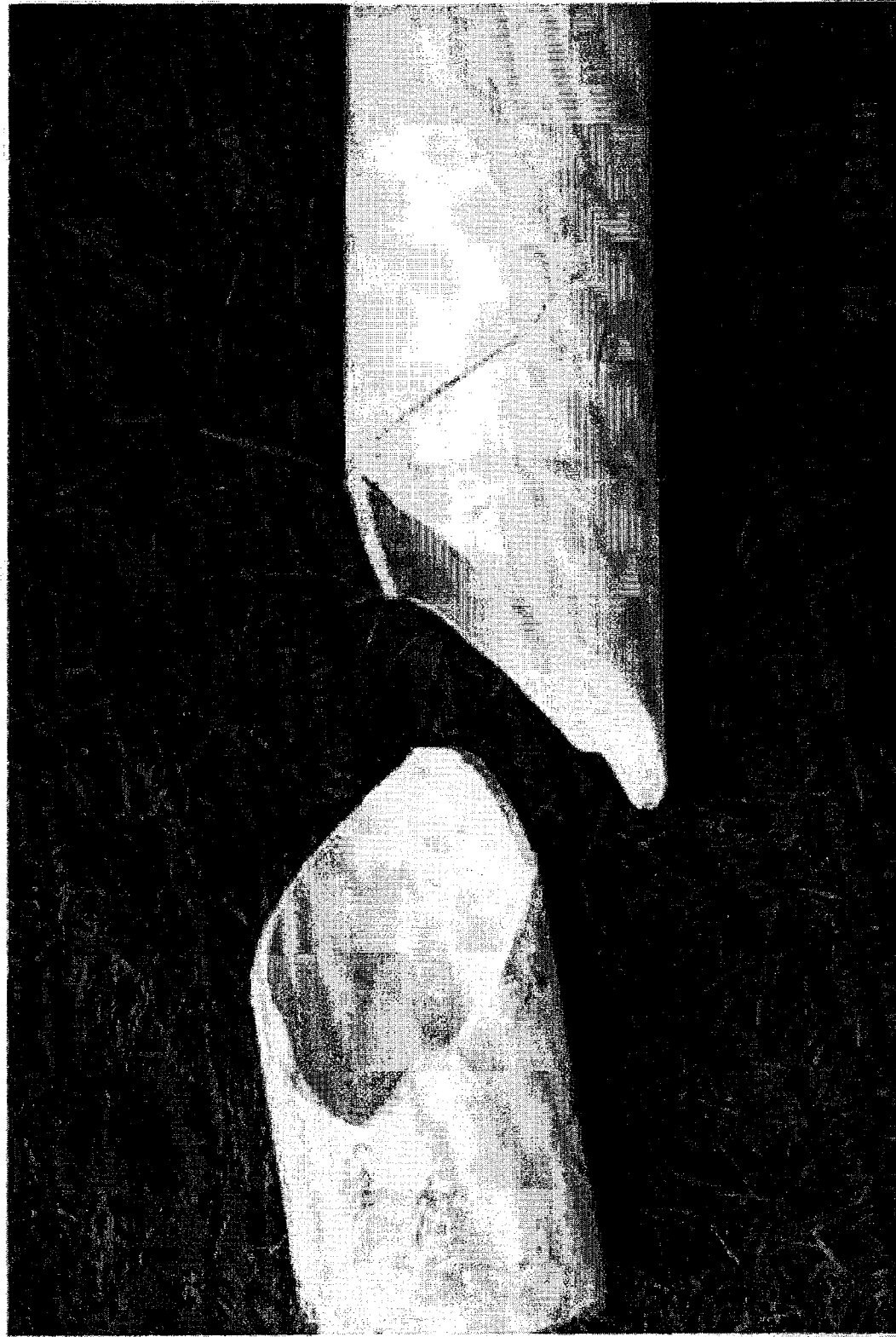


Known FPVC BF Failures

	BF Failure Location	Date of Failure	Pipe size
1	Young's Bay, OR	2007	8" DR 18
2	San Francisco, CA	2007	12" DR 14
3	Young's Bay, OR	2008	8" DR 18
4	Collier County, FL	2008	36" DR 25
5	Des Moines, IA	2008	20" DR 18
6	Guttenberg, IA	2008	12" DR 18
7	Bremerton, WA	2009	16"
8	London, ON	2009	450 mm DR 25
9	Baton Rouge, LA	2009	36" DR 32.5
10	Haynesville Shale, LA	2010	6" DR 18
11	Haynesville Shale, LA	2010	10" DR 18
12	Haynesville Shale, LA	2010	14" DR 18
13	London, ON	2010	450 mm DR 25
14	Pittsfield, IL	2010	18" DR 18
15	Plymouth, WI	2011	12" DR 18
16	SLC, Utah	2012	18" DR 26
17	Evansville, IN	2012	12" DR 18
18	SLC, Utah	2012	16" DR 31



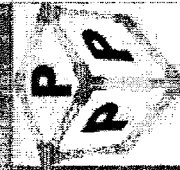
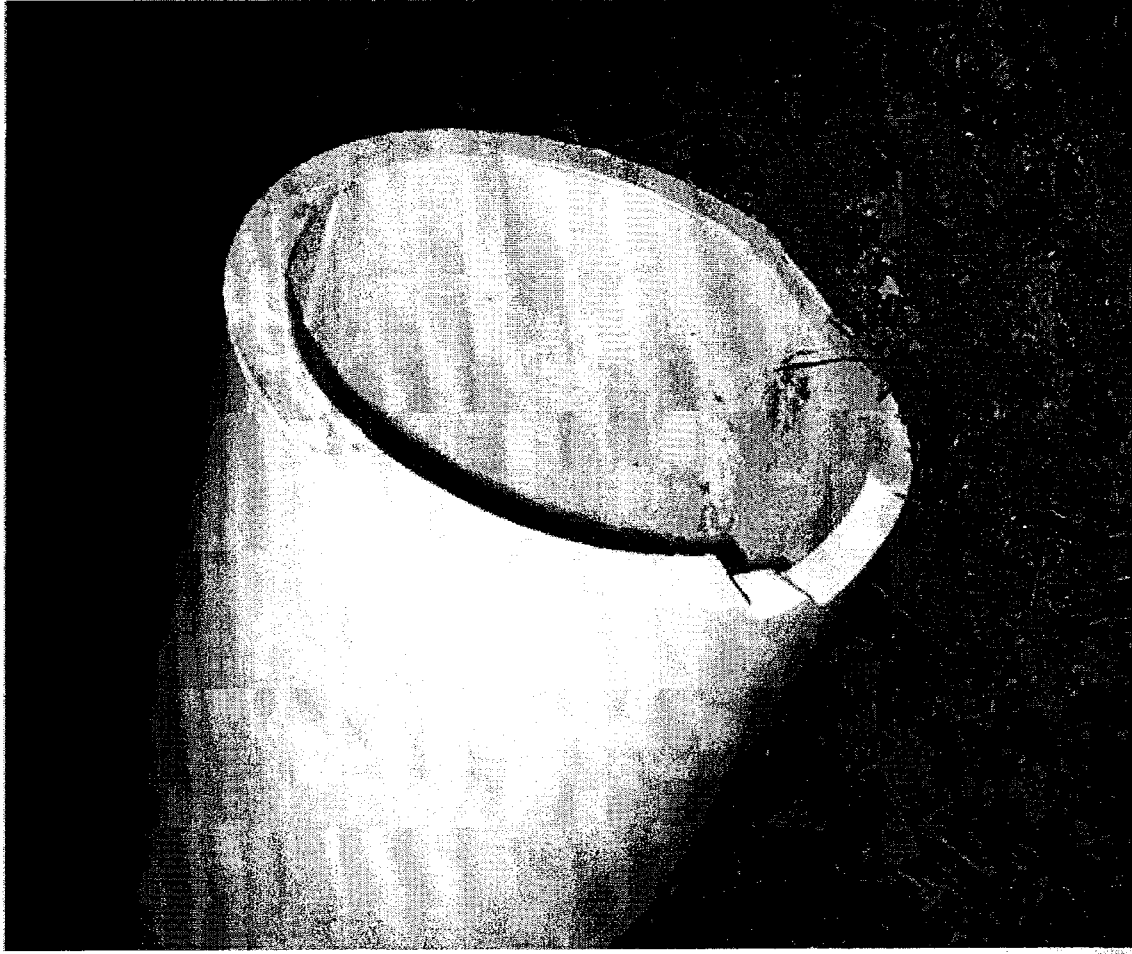
8" DR 18 PVC Pipe – Young's Bay, OR –



8" DR 18 PVC Pipe – Young's Bay, OR

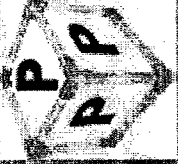


12" DR 18 PVC Pipe – Guttensburg, IA



LA Water Company

- TX Water Company installed many miles of butt fused PVC pipe in various pipe sizes – 6", 10", 14" – in the TX and LA area.
- They experienced many butt fusion failures in each of these pipe sizes.
- TX Water Company has replaced miles of butt fused PVC pipe due to these butt fusion failures.



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Butt Fusion Failures in PVC Pipe

- Known Butt Fusion Field Failures in PVC Pipe
- Joint Integrity Laboratory Data for PVC Pipe

Proposals to Prevent BF Failures in FPVC



Butt Fusion

- Butt fusion is one of the most common methods of joining thermoplastic pipe.
- Butt fusion joints provide a leak-free system with very good long-term performance.
- PE pipe butt fusion procedures were developed over 50 years ago.
- PVC pipe butt fusion procedures were recently developed, as discussed in a 2003 paper by David Woods and Tom Marti

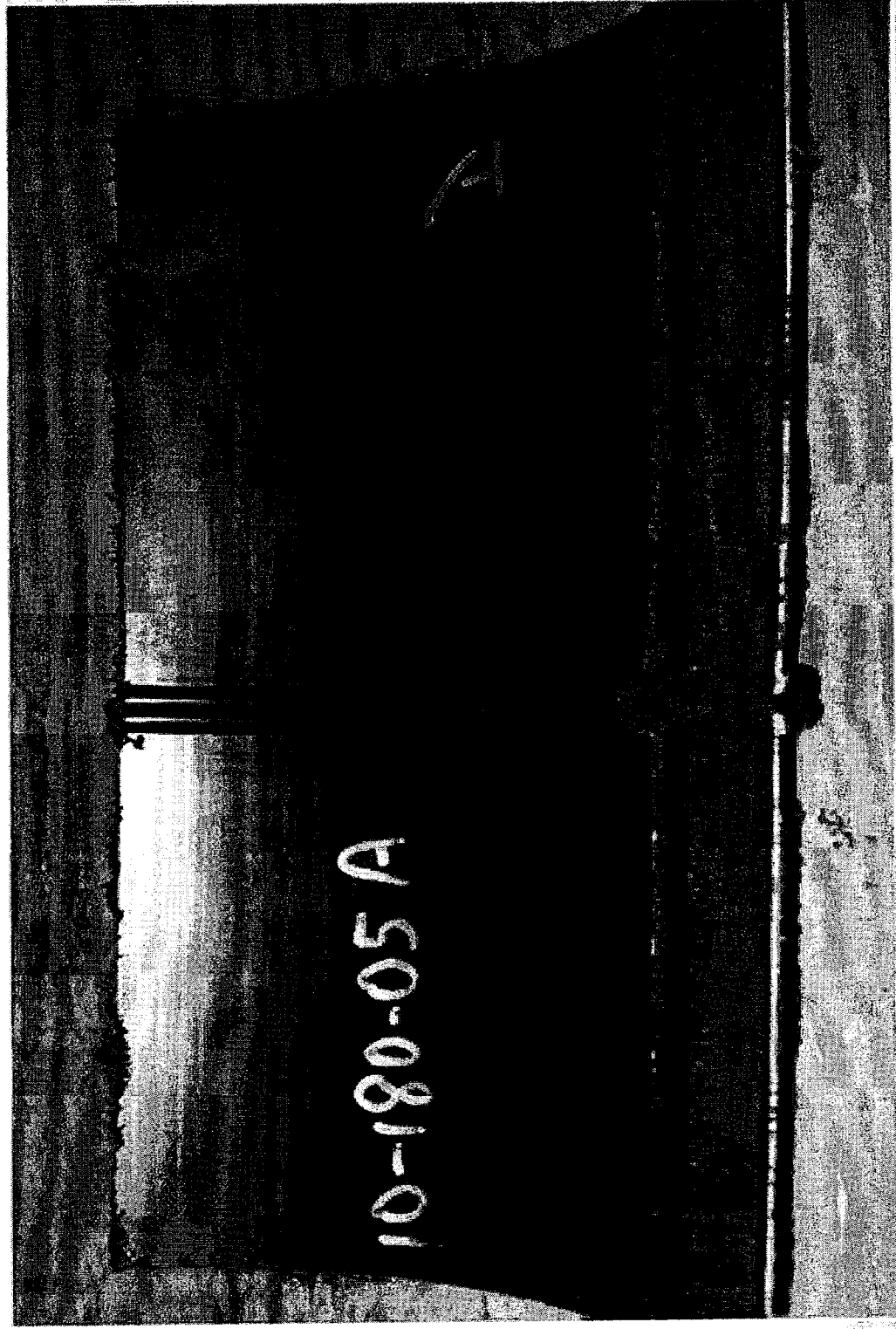


Background

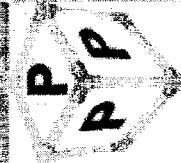
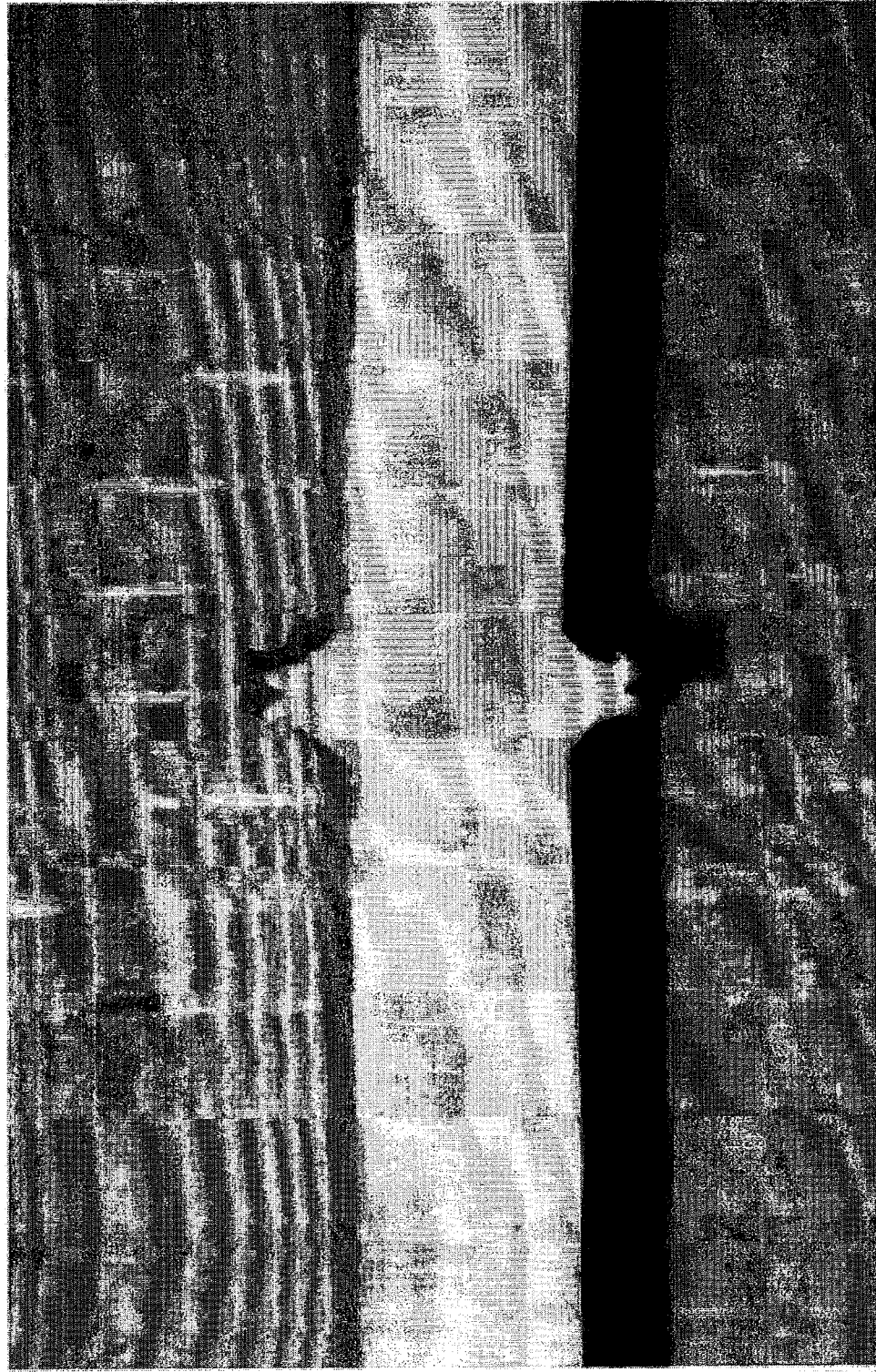
- A 3rd party lab was supplied with PE and PVC properly made butt fusion joints and control pipe samples.
- Standard ASTM test methods were used for butt fusion bead appearance and butt fusion joint integrity.
- This presentation summarizes a research program recently completed to assess the integrity of butt fusion joints for PE and PVC pipe using these ASTM test methods.



PE Visual Bead Appearance

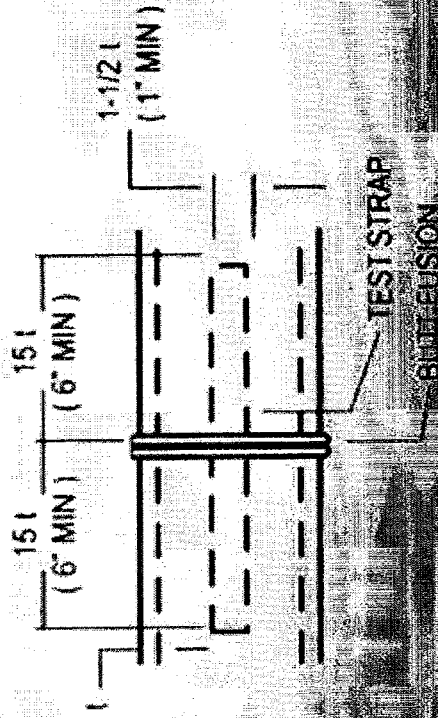
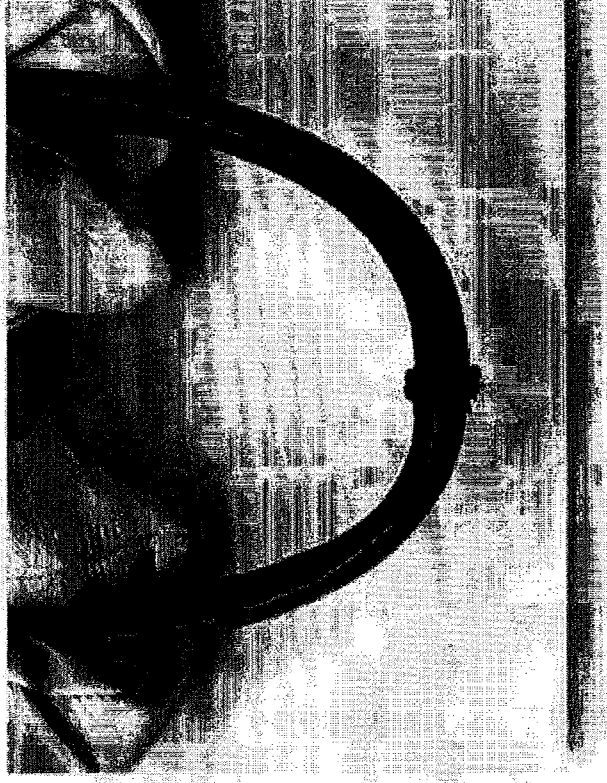


PVC Visual Bead Appearance



Bent Strap Test

- Similar in concept to the bend test performed on some steel welds and described in ASTM E190 "Standard Test Method for Guided Bend Test for Ductility of Welds"



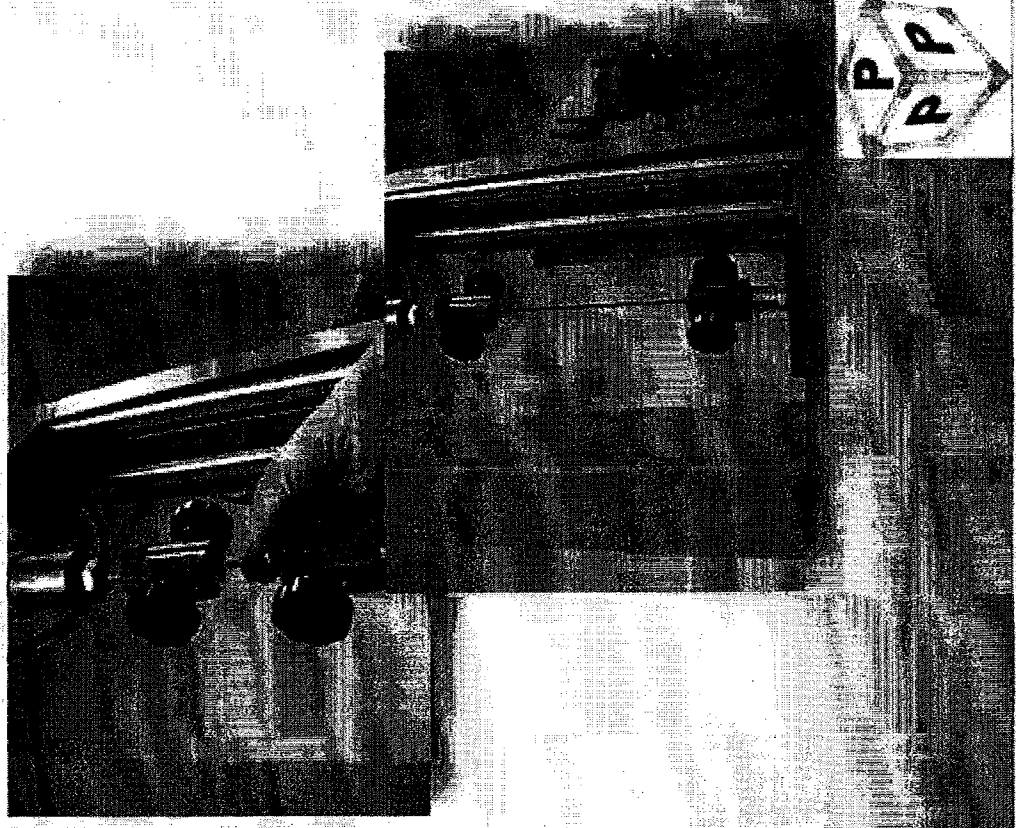
Test	Bent Strap
ASTM Test Method	D2657 & F2620
PE Butt Fusion	All fusions held
PVC Butt Fusion	All fusions broke



ASTM D638 Tensile Test

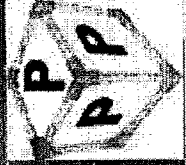
“Standard Test Method for Tensile Properties of Plastics”

- Test Method for determining tensile strength and elongation at break for plastic materials



PE Tensile Test Results – ASTM D638

Property	Average of Fusion Joint Results expressed as a % of the Average of the Pipe Control Results
Stress at Yield	96%
Elongation at Yield	107%
Stress at Break	104%
Elongation at Break	127%
Energy at Break	116%



PVC Tensile Test Results – ASTM D638

Property	Average of Fusion Joint Results expressed as a % of the Average of the Pipe Control Results.
Stress at Yield	N/A (Note 1)
Elongation at Yield	N/A (Note 1)
Stress at Break	85%
Elongation at Break	3%
Energy at Break	2.4%

Note 1 – The PVC butt fusion joints broke before yield

